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ABSTRACT

Relationships between an inquiry-oriented science inservice education program and teacher implementation of workshop-developed materials were investigated. Workshop topics included Piagetian learning theory, creating classrooms conducive to implementing inquiry-oriented science programs, use of the learning cycle, and matching learning activities to students' developmental stages. Workshop participants were matched with a control group of teachers who utilized the exposition method (reading and memorizing science concepts). A pretest-posttest design was used to measure the effects of the workshop on teaching methodology and on the knowledge organization and cognitive performance level of their students. These students were interviewed utilizing three Piagetian tasks (liquid, length, and weight) and nine objects (such as a marble) which they were to describe. Comparisons between the groups were made, noting the intellectual developmental levels and the language used when describing the objects. Since this research involved a thorough analysis of both the classroom environment and student interviews, an anthropological approach was used (with posttest data being collected during May 1985). Two findings from pretest data are these: intellectual development of experimental and control group students was approximately the same and experimental students could utilize property words better than control group students. (Author/JN)

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RESEARCH OF THE LEARNING CYCLE WITH THE ANTHROPOLOGICAL MODEL

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ABSTRACT

Research has helped to identify the processes that should be developed in an inquiry science program: observing, imagining, recalling, describing, comparing, generalizing, using numbers, classifying, evaluating, analyzing, synthesizing, deducing, measuring, interpreting evidence, inferring, predicting, and experimenting. An inservice workshop sponsored by the National Science Foundation was designed to help elementary school teachers develop these processes and prepare science curricula.

Participating teachers were instructed in the learning theories of Piaget. The workshop provided the teachers with experiences to help them develop classroom environments conducive to implementation of an inquiry science program. A teaching procedure, the "learning cycle," actively involved them in experimentation, discussion of scientific processes, and scientific record keeping and data analysis. The workshop experiences also prepared the teachers to match their teaching procedures with the level of intellectual development of their students and finally to develop learning cycles for their classrooms.

In this study the workshop participants were matched with a control group of teachers who utilized the exposition method (reading and memorizing science concepts). A pretest-posttest design was used to measure the effects of the inservice workshop on participant teaching methodology and ultimately on the knowledge organization and cognitive performance level of their elementary school students. The students were interviewed utilizing three Piagetian tasks (liquid, length, and weight) and nine objects (a magnet, a cotton ball, a marble, a seashell, a wooden square, a wooden triangle, a lead bar, a steel bar, and a plastic bar) which they were to describe. Comparisons between the students in the experimental group and the students in the control group were made noting the intellectual developmental levels and the language used when describing the objects.

This research involved a thorough analysis of both the classroom environment and the student interviews. For these reasons, an anthropological approach was used. The posttest data collection will be gathered during May, 1985.

INTRODUCTION

When used in science teaching, the inquiry method has been shown to increase the student's opportunity for social interaction and hands-on experiences in the classroom (Thompson and Voelker, 1970). Furthermore, opportunities such as those experienced in inquiry science teaching will accelerate movement through the stages of intellectual development, sensory-motor, preoperational, concrete, and formal operational (Ginsberg and Opper, 1969).

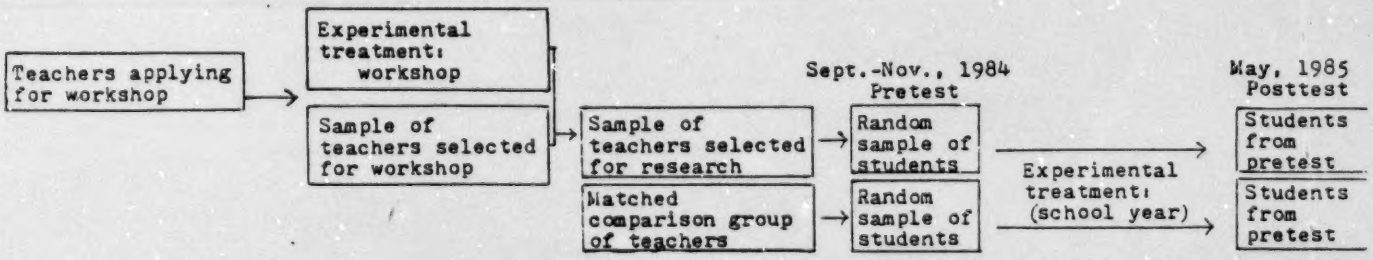
A review of the literature indicates that a vast amount of research has been done with science inservice education on inquiry teaching, and the conclusion can be drawn that positive results in participant attitude and implementation of new instructional approaches into the classroom are generally achieved (O'Sullivan, Piper, and Carbonari, 1981; Mayer, Disinger, and White, 1973). One of the most important effects of an inservice workshop is on the students of the participants (Bethel, 1982), but few studies have addressed this issue.

The purpose of this study was to investigate the relationships between inquiry science inservice education and teacher implementation of the workshop-developed materials. In addition, the student's performance on Piagetian tasks and language used by the student when describing objects was investigated.

DESIGN

This section contains a description of 1) the research sample selection process, 2) the workshop which is the experimental treatment in this study, and 3) the interview structure used with the students of the workshop participants.

The Sample


Teachers applying for workshop
Experimental treatment: workshop
Sample of teachers selected for workshop
Sept.-Nov., 1984 Pretest
Sample of teachers selected for research
Matched comparison group of teachers
Random sample of students
Random sample of students
Experimental treatment: (school year)
May, 1985 Posttest
Students from pretest
Students from pretest

The population for this study consisted of twenty-five elementary school science teachers from Oklahoma, Texas, and Colorado. The teachers were selected to attend the workshop of this study on 1) their willingness to utilize the workshop-developed science materials after returning to their school and 2) an explanation of why he/she wanted to attend the workshop. Sixteen of the initial twenty-five teachers were selected for the research study. These sixteen teachers taught in Oklahoma and had teaching assignments ranging from kindergarten through fifth grade. This group of sixteen teachers constituted the experimental group. The experimental group was asked to list names of teachers from their school that 1) had approximately the same amount of teaching experience, 2) taught the same grade level, and 3) taught science by exposition. From these lists, teachers were randomly selected by grades, and this group constituted the comparison group. Random samples of students from both the comparison and experimental teacher's classrooms were interviewed as an indication of workshop effectiveness. Interviews were used to measure the level of intellectual development of the student and the language used by the student to describe objects.

The Workshop

The science inservice education workshop of this research was sponsored by the National Science Foundation and was held five hours each week day for four consecutive weeks during the summer of 1984. The purposes of the workshop were for the participants to 1) understand that science is a search for knowledge and does not consist solely of the knowledge, 2) to understand that teaching science as a search for knowledge will lead students to construct their own knowledge about the world around them, 3) to understand how to develop instruction that will allow students to experience science as a search for knowledge, and 4) to understand how to develop a curriculum which both represents science and is compatible with their student's learning abilities.

During the workshop, the group was educated in the learning theories of Jean Piaget. The participants experienced a teaching procedure, the learning cycle, developed from Piaget's theory of intellectual development.

The learning cycle is made up of three phases which actively involved the participants with experimentation, observation, classification, discussion, and record keeping. During the first phase—Exploration—data were gathered through a series of activities such as experimenting, observing, interpreting, predicting, measuring, and model building. The teachers were provided with all of the essential materials for conducting the experiments. The data from the exploration were organized into charts, tables, or graphs and discussed by the class. The idea or concept being studied was then identified from the data during the second phase of the learning cycle—Conceptual Invention. Appropriate scientific language and terminology were provided during this phase. The concept was then applied to other areas and built upon through further experimenting, observing, interpreting, predicting, measuring, and model building in the third phase—Expansion.

After the participants experienced the learning cycle, they then used this teaching procedure by presenting learning cycles from the Learning Science program (Renner, Stafford, and Coulter, 1977) to the rest of the group. Following this activity, learning cycles were developed from a variety of traditional science textbooks and workbooks and presented to the class. The culminating activity involved the participants in developing learning cycles for usage in their own classrooms. Books and equipment were made available, and if desired, the teachers were able to work with the staff of the workshop or with other participants.

Interviews

The students were interviewed utilizing the three Piagetian tasks of weight, length, and liquid amount. These tasks indicated the level of intellectual development (Piaget's Theory: Conservation, San Francisco, California: John Davidson Film Corp.).

In addition to assessing cognitive developmental level, nine objects were shown to each student, and the language used in describing these objects was analyzed. The interviews were conducted from the fifth through the eleventh week of school, and the students in the experimental teacher's classroom had experienced approximatley three learning cycles.

Upon thorough examination of the pretest student interviews, three qualities were noted in the descriptive language of the students. The experimental and comparison students differed in 1) the language they used to describe the characteristics of the objects, 2) their ability to focus on the object in question without adding irrelevant information, and 3) their willingness to talk to the researcher.

Instrumentation

Classroom observations of the teachers in the experimental group and the classrooms taught by the teachers in the comparison group were made to determine the teaching procedures being used with the students. The criteria used to make this determination of teaching procedure involved 1) the classroom activities conducted by the experimental or comparison teacher, 2) the function of the experimental or comparison teacher during these activities, 3) the function of the experimental or comparison student during these activities, and 4) the sequence of activities as organized by the experimental or comparison teacher throughout a science unit (Grzybowski, 1985).

Comparisons between the experimental and comparison students were made utilizing an anthropological approach with a pretest-posttest design. Anthropological research—also known as ethnographic or qualitative research—is an investigative process conducted to gain a picture of the "way of life" of a group of people (Rist, 1979). The groups of people in this research are the elementary school science teachers and their students. The "way of life" refers to the science classroom

environment. Two data gathering strategies in the fieldwork of anthropological research are participant observation and interviews with individuals in the environment. Anthropological research allows the researcher to "get close to the data" thereby developing the analytical, conceptual, and categorical components of explanation directly from the data (Filstead, 1970). The following research is well suited to an anthropological model because it involves both observation of teacher's classrooms and analysis of individual interviews conducted with students.

RESULTS

Pretest data indicated that the intellectual development of both the experimental and comparison students was approximately the same. This data can be seen in Figure 1. Pretest data also indicated that the experimental students were better able to utilize property words. When shown a marble and asked to pick it up, feel it with their fingers, look at it closely, and describe it to the researcher, the comparison group usually responded that it could be used to play with or used in games. The experimental group noted much more about that object. It would roll, it was round, and it was yellow. In addition, the students in the experimental group seemed better able to focus on the object in question and talk only about the object. The comparison group often brought in additional irrelevant information. When describing the seashell, for example, a comparison child noted that "it was pretty, could be used in decorations, and could be hung from a net thing." The researcher considers that information irrelevent to describing the seashell. The experimental group was also much more willing to talk to the researcher perhaps due to the increased amount of social interaction both with peers and with their teacher in the experimental classroom. For example, four students in the comparison teacher's kindergarten classroom gave no answer to the majority of the questions. Such incidence of no response was not found in the entire experimental group.

Each student was interviewed by the researcher utilizing the script found in Figure 2. Figures 3 and 4 are typical dialogues transcribed from taped recordings of kindergarten and first grade student interviews. Figure 5 contains dialogues from two typical transition classrooms. The transition grade level is found in numerous schools today and is a grade level between kindergarten and first grade for placement of socially and intellectually immature students.

EXPERIMENTAL

Grade	Sample size	Percent of students able to conserve Length	Weight	Liquid amount
Kindergarten	10	10	40	30
Transition	20	20	30	30
First	39	51	56	46
Second	40	80	80	53
Third	39	92	79	69
Fifth	10	90	90	80

COMPARISON

Grade	Sample size	Percent of students able to conserve Length	Weight	Liquid amount
Kindergarten	10	40	50	50
Transition	10	20	40	30
First	19	53	53	42
Second	30	83	70	53
Third	30	90	80	67
Fifth	10	100	90	90

Figure 1 Conservation abilities of experimental and comparison groups.

1 - (magnet) - I have a magnet that I would like to show you. I would like for you to look closely at both the magnet and these things that go on top of it. Pick them up and touch them with your fingers. If you would like to, you may put these things on top of the magnet. Could you tell me everything you can about all of these things?

2 - (marble) - I have a marble that I would like to show you. Pick it up and feel it with your fingers. Look at it closely. Please tell me everything you can about the marble.

3 - (bars) - I have three bars that I would like to show you. I would like for you to pick them up and feel them with your fingers. Look at them closely. Tell me everything you can about these three bars.

4 - (cotton ball) - I have a cotton ball that I would like to show you. Please pick it up and feel it with your fingers. Look at it closely. Please tell me everything you can about the cotton ball.

5 - (seashell) - I have a seashell to show you. I would like for you to pick it up and touch all the parts of it with your fingers. Look at it closely. Tell me everything you can about the seashell.

6 - (wooden square) - I would like for you to pick this up and feel it with your fingers. Look at it closely. Please tell me everything you can about this thing. (If the child does not mention the name of the shape during the interview, I will ask them the name.)

7 - (wooden triangle) - I would like for you to pick this up and feel it with your fingers. Look at is closely. Please tell me everything you can about this thing. (If the child does not mention the name of the shape during the interview, I will ask them the name.)

Figure 2 The language utilized by the student when describing an object was assessed utilizing these statements and questions. The statements and questions are numbered in the exact sequence in which they were administered to each student.

The following responses were taken from an experimental student that was able to conserve weight but unable to conserve liquid amount or length.

1 - One of these small ones are different from all of these other small ones and is more rounder. The big, black magnet is bigger than the others, and it's also a different color. That's all.

2 - Right here it's darker I mean lighter than right here. It looks like it's yellow on the outside, but it's really clear white. That's all.

3 - Two of them are magnets, and one is plastic. Two are metal and one is plastic. They are all different colors. This is lighter than this one, and this one is a different color than both of them. These two are bigger than the green one, and that's all.

4 - It's white and it looks like a snake. It is soft. That's all.

5 - It's white, has white lines, and it's got brown lines with the white ones. Right here the lines are smaller than these right here. This line is twirly, and these aren't. When you put your ear against it, it will feel like the seashore. Some animals live in seashells. They build houses, and that's all.

6 - It's yellow, has four sides, it's dark yellow or brownish yellow. That's all.

- A square.

7 - It's red, it's got three sides, it's got three points, it has three straight lines, and it's a triangle. That's all.

The following responses were taken from a comparison student that was able to conserve length but unable to conserve weight or liquid amount.

1 - They are screwdrivers and they're all little. That's all.

2 - It can roll. You can play games with it and do other things with it. It's hard. That's all.

3 - These are not alike and these are alike. You can make crosses with them. You can make a pair of pants. You can make an arm with one of them. You can make legs. That's all.

4 - It's soft. You can put it in your ears when your ears hurt. It can tear apart. That's all.

5 - It's plastic. You find it at the sea. You find them in the country. It can break because it's glass.

6 - It's soft. You can hit your finger with it, and it won't even hurt. That's all.

- square

7 - It's hard. It's a triangle, and you can play with it. That's all.

Figure 3 These responses were taken from taped recordings of two typical kindergarten students. Their responses are numbered to match the researcher's statements and questions which are listed in Figure 2.

The following responses were taken from an experimental student that was unable to conserve weight, length, or liquid amount.

1 - They're metal, they're hard, they're round, they got sharp ends, and that's all.

2 - It's yellow, has stuff in it, it's round, got stuff in it, it's a ball, and that's all.

3 - They're silver, one is green, they're straight, they got hard ends, they can't bend, and that's all.

4 - It's soft, it's white, you can bend it, you can stretch it, you can break it, and that's all.

5 - It's hard, it's glass, it's straight here, it's a circle, it's got sounds inside of it, it came from the ocean, and that's all.

6 - It's brown, it's a block, it's hard, it's got sharp ends, it's wood, and that's all.

- It's a square.

7 - It's red, it's a triangle, it's got sharp ends, and that's all.

The following responses were taken from a comparison student that was unable to conserve weight, length, or liquid amount.

1 - I forgot.

2 - You can play with it.

3 - You can play with them, you can spin around on them, and that's all.

4 - You can put medicine on it and put it on your leg. That's all.

5 - You can hear the ocean and you can play with it. That's all.

6 - You can play blocks with it and you can build stuff with it. You can throw it back and forth easy. That's all.

- square

7 - You can build people with it and make shapes with it. That's all.

- triangle.

Figure 4 These responses were taken from taped recordings of two typical first grade students. Their responses are numbered to match the researcher's statements and questions which are listed in Figure 2.

The following responses were taken from an experimental student that was able to conserve weight, length, and liquid amount.

1 - This one's big, and this one's little. They stick. They stick because they're metal. This is heavier than this one. That's all.

2 - It's smooth, and it's kind of little. It's yellow. It has a little bit of dirt on it. It has a tiny hole in it.

3 - These two are heavy. This one's light. One of these is silver, and one of them is gold. This one is green. These two are metal, and this one's plastic. That's all.

4 - It's soft. It's white. It has a little bit of fuzz on the end. You can roll it into a ball. That's all.

5 - It swirls. You can put it on your hand like a boxing glove. It has a little bit of holes in it and cracks on the sides. It has bumps on it, and on the inside it has white stuff. That's all.

6 - It's yellow. It's a square. You can put it on the corner, and it's a diamond. It has four corners. That's all.

7 - It's red, has three edges, three corners, and that's all.

- triangle

The following responses were taken from a comparison student that was able to conserve weight but unable to conserve length or liquid amount.

1 - They're skinny, and in the middle of them they're bumpy. One is bigger.

2 - It's round and has colors in it. That's all.

3 - They're long. They're skinny. One's green. One's gray. They're smooth.

4 - It's squishy. It's bendy. It's soft.

5 - It has little bumps. It's twisty a little bit, and inside of it has dots.

6 - It's a square. It's smooth. It's hard. That's all.

7 - It's a triangle and smooth, and it's hard. It has three corners.

Figure 5 These responses were taken from taped recordings of two typical transition students. Their responses are numbered to match the researcher's statements and questions which are listed in Figure 2.

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